Annual Report for FY19

Sustaining rural communities through new water management technologies

Progress Report

The Ogallala Aquifer Program (OAP) is a research and education consortium seeking solutions to problems arising from declining water availability from the Ogallala Aquifer on the Southern High Plains. The consortium includes Kansas State University, Texas A&M AgriLife Research and Extension Service, Texas Tech University, West Texas A&M University, and the USDA ARS National Program 211 research projects at Bushland and Lubbock, TX. OAP funding is from the USDA ARS at Bushland, and OAP management is led by ARS at Bushland with cooperation of a management team composed of the principle investigators for the funding agreements with the four universities.

University and ARS collaborators in the OAP produced 22 publications in FY19 and in prior years that were not reported previously. These are listed in the publications for this research project. These publications support the 11 substantive accomplishments reported here.

Accomplishments

Subsurface drip irrigation saved six inches of irrigation when watering corn. In the face of declining water supplies, it is important for economic sustainability to maximize the yield per unit of water used in crop production, the so-called crop water productivity or CWP. It is not well understood how irrigation application method affects the CWP. Increasing CWP in the face of limited water supplies is a key objective in irrigation and agronomic research because it directly affects profitability, water sustainability and intensification of agricultural production. The irrigation application method can have an effect on CWP that is as large as or even larger than the effects of irrigation scheduling. ARS scientists at Bushland, Texas, compared the water use and yield of grain corn and sorghum grown using sprinkler and subsurface drip irrigation (SDI) methods. Using the SDI application method, loss of water to evaporation from plant and soil surfaces was reduced by two to more than five inches compared to the loss suffered with sprinkler irrigation. Using SDI reduced overall corn water use by up to six inches while increasing yields by up to 20% compared with sprinkler irrigation. Although the SDI system is more expensive to install than are sprinkler irrigation systems, the benefits of SDI are convincing in the dry climate of the Southern High Plains. Using SDI can result in long-term gains in profitability and sustainability of irrigated grain production.

Response of dryland grain sorghum to no-till varied with locations in Texas and Kansas. As water availability for irrigation from the Ogallala Aquifer decreases, producers are growing crops on more dryland acres. The yield and profitability of dryland farming is heavily dependent on the fraction of rainfall that is used by the crop. Tillage can influence rainfall capture by the soil, however no-till has shown mixed results across the U.S. Great Plains in improving sorghum grain yield compared with reduced or conventional tillage. ARS scientists from Bushland, Texas, and researchers from Kansas State University evaluated the amount of rainfall that infiltrated the soil as well as that lost to evaporation and drainage during phases of a winter wheat-sorghum-fallow rotation under no-till and reduced tillage. The study was carried out at Bushland, Texas, and at Tribune, Kansas, two locations with very different soils. Deep drainage comprised only a small proportion of available water lost to the cropping system. Evaporation during summer fallow periods was not reduced under no-till at both locations. At the Bushland location, tillage did not significantly influence infiltration, soil water available to crops, and long-term sorghum yield. At the Tribune location, cumulative rainfall infiltration was 60% greater under no-till compared with reduced tillage and increased water available to sorghum during the growing season, thus explaining the long-term 35% sorghum yield advantage compared with reduced tillage. The study demonstrates that no-till does not perform similarly across all soil types and environments in increasing effective rainfall that is available to crops. Both farmers and crop consultants need to use tillage regimes that are tailored to their soils and local conditions rather than using generalizations.

Uniformity of irrigation applications affects the profitability of corn. Optimized scheduling of irrigation for crops can reduce water and energy use and increase profit. However, the uniformity of the applied irrigation across the field can reduce the success of improved scheduling. The effect of a marginally acceptable irrigation uniformity on corn yields and profitability was studied by ARS scientists at Bushland, and researchers from Texas, and Centro Regional de Estudios de Agua (CREA) University of Castilla-La Mancha, Albacete, Spain. In a field where the crop received more irrigation than required, grain yields were maximized. When irrigation was scheduled to match crop requirements, grain yields were reduced by 8%. Although optimal scheduling met crop water requirements on an area-averaged basis, parts of the field received less than what the crop required because of marginal uniformity. Farmers and crop consultant need to ensure that irrigation application is uniform to get the most out of irrigation scheduling practices.

Commercially available soil moisture sensor can be used to schedule irrigation applications. The amount of freshwater available for irrigation is decreasing worldwide, and, therefore, application of irrigation water needs to be more efficient if crop yields are to be maintained. The use of soil water sensors is commonly thought to aid irrigation management in crop production systems. However, limited studies explore how sensor type, installation technique, sensor orientation, and soil texture affect sensor accuracy. ARS researchers from Bushland, Texas, along with scientists from Texas A&M University compared soil water measurements from four commercially available sensors installed at three depths and orientations with co-located neutron probe moisture meter (NMM) readings. Results from paired comparisons indicated that sight-specific sensor calibrations were required for accurate estimation of soil water content for the clay loam soil. However, soil profile water content values integrated from one sensor compared well with values integrated using NMM readings. These results suggest that some factory calibrated sensors may be useful for irrigation scheduling, if installed properly. Farmers and crop consultants that are trying to optimize irrigation applications can benefit from the data from these soil moisture sensors.

Alternatives to corn for water limited areas. Decreased irrigation well capacities due to declining groundwater levels in the Ogallala Aquifer will eventually limit the production of corn in the Northern High Plains of Texas, one of the region's most profitable crops. Alternatively, less water intensive crops may conserve groundwater while allowing producers to remain profitable. Therefore, scientists from ARS in Bushland, Texas, and Texas A&M AgriLife Research and Extension Service used the hydrologic model Soil and Water Assessment Tool (SWAT), equipped with a newly developed irrigation program to simulate water use associated with alternative crops including soybean, sunflower and grain sorghum. Results indicated irrigation amounts were reduced by 19, 21, and 32% respectively, as compared to corn. These results are of interest to farmers, crop consultants and regional water policy makers to identify crops other than corn that can be used under conditions of limited groundwater availability.

Hydrologic model SWAT modified to simulate management allowed depletion of soil water. Water scarcity due to drought and groundwater depletion has led to an increased emphasis on irrigation strategies for extending limited water resources. One effective strategy is to irrigate when soil water decreases to the so-called management allowed depletion (MAD). The Soil and Water Assessment Tool (SWAT), a widely used hydrologic model, is increasingly being used to evaluate the impacts of irrigation strategies. However, deficiencies in default auto-irrigate functions in SWAT resulted in the development and localized testing of an alternative algorithm based on the MAD strategy. Therefore, ARS scientists from Bushland, Texas, along with researchers from Texas A&M AgriLife further evaluated the MAD algorithm by comparing simulated irrigation, crop water use, plant growth, and yield to measured values for corn grown at multiple research sites across the Southern Great Plains. Results indicated that the alternative MAD function outperformed the default auto-irrigation algorithms in SWAT. SWAT has become widely used as a tool for water planning and water policy makers. Prior to this accomplishment, however, SWAT did not simulate irrigation of crops in a means that mimic real-world situation. Therefore, inclusion of this new code will greatly increase the applicability of the model to areas where irrigation occurs, which will assist regional water planners.

New model developed to estimate corn water use. Predicting crop water use is important for conserving water and managing irrigation, and for maximizing farm profits. Corn is profitable but has a high water requirement. Water use by corn can be predicted by models; however, these models are not always accurate and can be too complex for use by farmers and crop consultants. Therefore, ARS scientists from Bushland, Texas, and Kansas State University researchers tested a new crop water use model that was designed to achieve accuracy across different locations without being overly complex. The model accurately predicted the water use by corn for an entire growing season in Bushland, Texas. The model did not require calibration for the windy conditions of Texas. Therefore, the new model will help farmers conserve water and increase farm profits by ensuring that corn is not over-irrigated.

Improvements in the use of remotely sensed images to estimate crop water use. As irrigation water available from the Ogallala Aquifer decreases, farmers need to better match irrigation applications to water needs of the crop. Maps of crop water use across large agricultural regions are useful for drought detection and prediction, and management of water resources. Maps of crop water use can be produced by combining satellite images and weather data. The satellite images usually have coarse resolution, from 100 m to 1 km. The weather data are obtained continuously from weather stations that are located as discrete spots. The spaces between the weather station points can be filled using models so that weather data can have the same locations as the satellite data points to produce the crop water use maps. However, filling the spaces between the weather stations causes loss of accuracy. Therefore, ARS scientists at Bushland, Texas, and Kansas State University researchers developed and tested a new method to improve the accuracy of crop water use maps. The improved accuracy will provide earlier detection of crop water stress, and will improve farm profitability by better matching crop water use with irrigation applications.

Drought tolerant corn yields better with less irrigation. The Texas High Plains is a major corn producing region, but drought and diminishing availability of irrigation water threaten to reduce production. Drought resistant corn varieties and different seeding rates may be tools that farmers can use to continue to produce corn in the region. Two different experiments confirmed that drought tolerant corn yields better than conventional corn at less than optimal irrigation levels. In one study, ARS scientists from Bushland, Texas, along with researchers from Texas A&M AgriLife Research, the University of Arizona, a commodity group, and a commercial seed company, compared a new drought tolerant variety to a conventional corn variety. In a second set of experiments, ARS scientists at Bushland, Texas, and researchers from Texas A&M AgriLife Research tested two drought tolerant maize varieties under three irrigation rates and three planting densities at Etter, Texas. At smaller irrigation rates, the drought tolerant variety produced greater grain compared with the conventional variety. Grain yield increased slightly with higher planting densities, but this may not offset the greater cost in seed. These data will provide maize farmers with management guidelines for maximizing farm profits while conserving water.

Recent expansion of Texas High Plains dairy simulates regional agricultural economy. The dairy industry in the southern High Plains has experienced rapid expansion in the past two decades. ARS researchers at Bushland, Texas, assessed the impact of the increased presence of dairies on overall water use, crop composition, and the local economy. The increase in water use related to the dairy industry from 2000 to 2015 was primarily due to an increase in demand for drinking by the cows (direct water) as well as an increased demand for silage (indirect water). However, a comparative analysis (dairy presence vs. no dairy presence) from a single year indicates minimal impacts on total water use due to dairies. During the same time period, the number, size, and employment of related local business establishments have increased economic activity in rural areas. These results demonstrated that the establishment of a high value product relative to water use can stimulate a regional agricultural economy while having little impact on groundwater withdrawals.

Winter wheat rotations provide maximum soil water at planting for summer crops. As the availability of irrigation water from the Ogallala Aquifer decreases, it is likely that the area being managed for dryland crop production will increase. Dryland crop rotation systems are sustainable only if there is sufficient water available for profitable crop production. However, crop rotations that promote sustainable production have not been determined. The objective of this study by scientists from Kansas State University in the ARS-led Ogallala Aquifer Program was to identify potential crop rotation systems for the central Great Plains from 2000 through 2017 using four summer crops [corn, grain sorghum, soybean, and sunflower] and winter wheat in 1-, 2-, 3-, and 4-year rotations. Results showed that available soil water at planting of the summer crop was greatest in rotations in which winter wheat was immediately prior, probably due to the longer fallow period to store rainfall. These results are of interest to farmers and crop consultants in establishing rotations appropriate for dryland crop production on the Southern High Plains.

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